Progress Report on the Second Year of AISR Grant: NAG5-11996
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Scalable Algorithms for Fast Analysis of Megapixel CMB Maps
and Large Astronomical Databases
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Motivated by the release of the First Year WMAP data, we have been continuing the development of our fast analysis techniques and codes. Our principal focus has been to meet the practical challenges of real data. We fully upgraded SpICE such that it can now deal with WMAP data release: we have included non-Gaussian beam corrections, cross correlations. We have integrated SpICE into a processing pipeline, which includes Monte Carlo simulations, and post-processing. In addition, we have enabled galaxy-CMB cross-correlations and galaxy-galaxy correlations. This enables the SDSS-WMAP cross-correlation analysis, as well as SDSS clustering analyses.

1 SpICE and WMAP

After the release of the First Year WMAP data, we have reexamined our code in detail, and upgraded it to cope with the real life challenges the data posed. As a result, we have implemented the following new following novel features into SpICE:

- Cross correlation support: while the previous version focused on autocorrelation, the data is exclusively processed via cross correlation due to the noise properties.
- General non-Gaussian beam corrections: the previous version assumed Gaussian beam which turned out to be a bad approximation.
- Monte Carlo simulation pipeline: we have integrated SpICE into a full WMAP simulation pipeline, which simulates the channels with realistic noise and sky coverage. This is crucial for estimating the errors.
- Post processing pipeline: this is used both for analyzing the simulations and the real data. It includes implementation of the three weighting schemes recommended by the WMAP collaboration for the different ℓ-ranges (low, medium, high), and point source subtraction.
- We have included new features which enable the processing of galaxy catalogs, as well galaxy-CMB cross correlations. In particular, we introduced the method of C_l-apodization to regularize the oscillations due to the aliasing caused by undersampling using Healpix harmonic transform.

The present speed of SpICE is 8-10 minutes per cross correlations, depending on the speed of the node. WMAP has 28 pairs of channels, and we had to analyze 300 realizations per channel, which amounted to 8400 simulations. This took about 3 days of CPU on our 20 CPU Beowulf cluster built last year. The total number of simulations with the different weighting schemes were about twice the above amount.

This new version of SpICE and the corresponding analysis pipeline is now at the level that it is able to analyze the full WMAP release. At the time of this writing (to our best knowledge), our analysis represents the only independent confirmation the original WMAP results. Next I show one of our SpICE measurements compared with the published WMAP power spectrum..

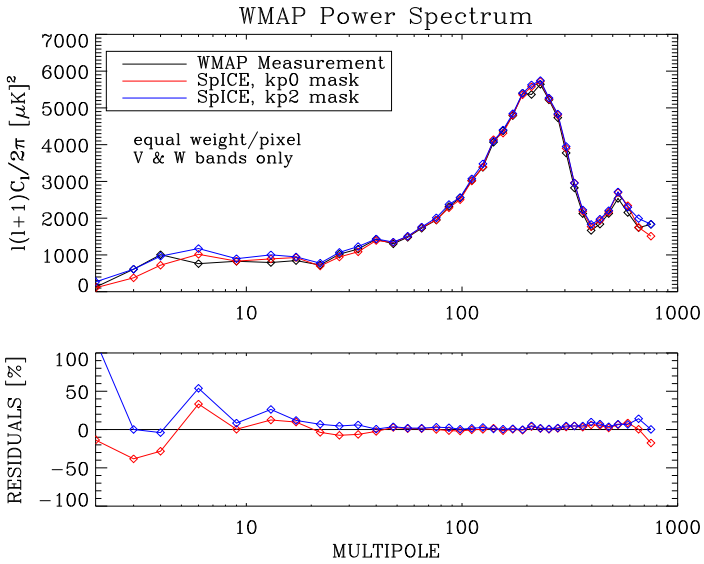

Figure 1: SpICE applied to the WMAP first year data. The cross correlations of the V and W channels are used and compared with the fiducial WMAP measurement of Spergel et al. (2003). The two curves show the effects of two different galactic cuts recommended by the WMAP team. Note the excellent agreement between our analysis and that of the WMAP team from about $20 \gtrsim l \gtrsim 600$. The agreement is within cosmic variance on all scales.

2 eSpICE status

We have implemented a new API for correlation function measurements. It has been used in Budavári et al. (2003). Presently we are working on add power spectrum and bispectrum support for eSpICE, the Euclidean version of SpICE. As an example I show a bispectrum measurement in a 2LPT (second order Langrangian) simulation with theory. It appears that the preliminary power spectrum estimator works correctly.

3 Plans

Keeping in pace with our original proposal, further improvements and generalizations are planned to enhance our present array of analysis tools. Our focus for the third year will be generalizations to higher order correlation functions, in particular for three-point correlation functions and bispectra.

Relevant Publications in this term are the following: Challinor et al. (2003); Chon et al. (2003); Szapudi & Kaiser (2003); Budavári et al. (2003); Szapudi & Pan (2004)

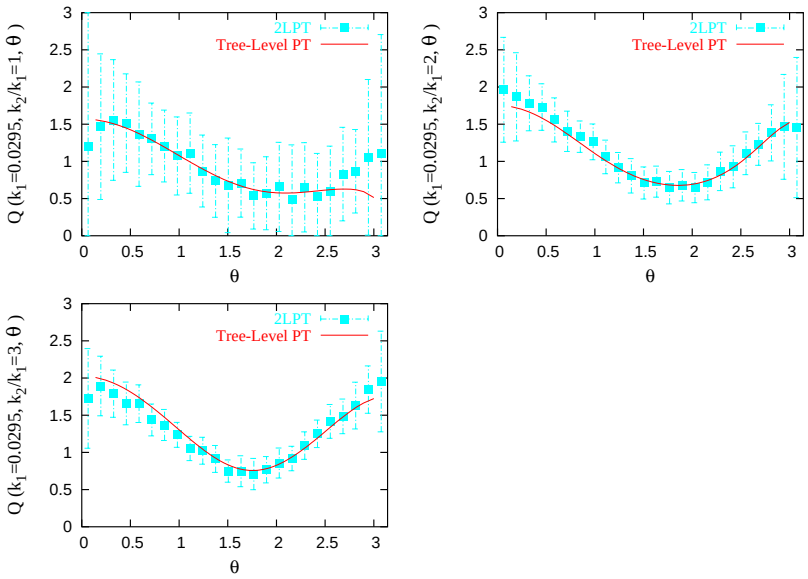

Figure 2: The bispectrum measured with eSpICE and a postprocessing program. The solid line is based on Eulerian Perturbation Theory, while the measurements were made in large 2LPT simulations. They show that the preliminary code is working.

References

Budavári, T., et al. 2003, ApJ, 595, 59

Challinor, A., Chon, G., Hivon, E., Prunet, S., & Szapudi, I. 2003, New Astronomy Review, 47, 995

Chon, G., Challinor, A., Prunet, S., Hivon, E., & Szapudi, I. 2003, ArXiv Astrophysics e-prints

Spergel, D. N., et al. 2003, ApJSupp, 148, 175

Szapudi, I., & Kaiser, N. 2003, ApJLett, 583, L1

Szapudi, I., & Pan, J. 2004, ApJ, 602, 26